SUMMARY OF RESEARCH NASA GRANT NAG5-11008

Publications

Molinari, J., D. Vollaro, and K.L. Corbosiero, 2004: Tropical cyclone formation in a sheared environment: A case study. *Journal of the Atmospheric Sciences*, **61**, 2493-2509.

Molinari, J., P. Dodge, D. Vollaro, K.L. Corbosiero, and F. Marks, Jr., 2005: Mesoscale aspects of the downshear reformation of a tropical cyclone. *Journal of the Atmospheric Sciences*, accepted.

Heymsfield, G.M., J. Halverson, E. Ritchie, J. Simpson, J. Molinari, and L. Yian, 2005: Structure of the highly sheared Tropical Storm Chantal during CAMEX-4. *Journal of the Atmospheric Sciences*, accepted.

Because the last two papers above are not yet in print, the abstracts are given below:

Mesoscale Aspects of the Downshear Reformation of a Tropical Cyclone

The downshear reformation of Tropical Storm Gabrielle (2001) was investigated using radar reflectivity and lightning data that were nearly continuous in time, as well as frequent aircraft reconnaissance flights. Initially the storm was a marginal tropical storm in an environment with strong 850-200 hPa vertical wind shear of 12-13 ms^{-1} and an approaching upper tropospheric trough. Both the observed outflow and an adiabatic balance model calculation showed that the radial-vertical circulation increased with time as the trough approached. Convection was highly asymmetric, with almost all radar return located in one quadrant left of downshear in the storm. Reconnaissance data show that an intense mesovortex formed downshear of the original center. This vortex was located just south of, rather than within, a strong downshear left lightning outbreak, consistent with tilting of the horizontal vorticity associated with the vertical wind shear. The downshear mesovortex contained a 972 hPa minimum central pressure, 20 hPa lower than minimum pressure in the original vortex just three hours earlier. The mesovortex became the new center of the storm, but weakened somewhat prior to landfall. It is argued that dry air carried around the storm from the region

of upshear subsidence, as well as the direct effects of the shear, prevented the reformed vortex from continuing to intensify.

Despite the subsequent weakening of the reformed center, it reached land with greater intensity than the original center. It is argued that this intensification process was set into motion by the vertical wind shear in the presence of an environment with upward motion forced by the upper tropospheric trough. In addition, the new center formed much closer to the coast and made landfall much earlier than predicted. Such vertical shear-induced intensity and track fluctuations are important to understand, especially in storms approaching the coast.

Structure of the Highly Sheared Tropical Storm Chantal During CAMEX-4

Tropical Storm Chantal during August 2001 was a storm that failed to intensify over the few days prior to making landfall on the Yucatan Peninsula. An observational study of Tropical Storm Chantal is presented using a diverse data set including remote and in situ measurements from the NASA ER-2 and DC-8 and the NOAA WP-3D *N42RF* aircraft and satellite data. The authors discuss the storm structure from the larger scale environment down to the convective scale. Large vertical shear (850-200 hPa shear magnitude range 8-15 ms^{-1}) plays a very important role in preventing Chantal from intensifying. The storm had a poorly defined vortex that only extended up to 5-6 km altitude, and an adjacent intense convective region that comprised an MCS. The entire low-level circulation center was in the rain-free western side of the storm, about 80 km to the west-southwest of the MCS. The MCS appears to have been primarily the result of intense convergence between large scale, low-level easterly flow with embedded downdrafts, and the cyclonic vortex flow. The individual cells in the MCS such as Cell 2 during the period of the observations, were extremely intense with reflectivity core diameters of 10 km and peak updrafts exceeding 20 m s^{-1}. Associated with this MCS were two broad subsidence (warm) regions both of which had portions over the vortex. The first layer near 700 hPa was directly above the vortex and covered most of it. The second layer near 500 hPa was along the forward and right flanks of Cell 2 and undercut the anvil divergence region above. There was not much resemblance of these subsidence layers to typical upper level warm cores in hurricanes that are necessary to support strong surface winds and a low central pressure. The observations are compared to previous studies of weakly sheared storms and modeling studies of shear effects and intensification.

The configuration of the convective updrafts, low-level circulation, and lack of vertical coherence between the upper and low level warming regions, likely inhibited intensification of Chantal. This configuration is consistent with modeling of vortices in sheared environments, which suggest strongest convection and rain in the downshear left quadrant of the storm, and subsidence in the upshear right quadrant. The vertical shear profile is however different from what was assumed in previous modeling in that the winds are strongest in the lowest levels and the deep tropospheric vertical shear is on the order of 10-12 m s^{-1}.